

## Assessment of Air Quality in the Shuttle and International Space Station (ISS) Based on Samples Returned by STS-105 at the Conclusion of 7A.1

The toxicological assessment of air samples returned at the end of the STS-105 (7A.1) flight to the ISS is reported. ISS air samples were taken in August 2001 from the Service Module, FGB, and U.S. Laboratory using grab sample canisters (GSCs) and/or formaldehyde badges. Preflight and end-of-mission samples were obtained from *Discovery* using GSCs. Analytical methods have not changed from earlier reports, and surrogate standard recoveries were 64-115%. Pressure tracking indicated no leaks in the canisters.

The two general criteria used to assess air quality are the total-non-methane-volatile organic hydrocarbons (NMVOCs) and the total T-value (minus the CO<sub>2</sub> and formaldehyde contribution). Because of the Freon 218 (octafluoropropane, OFP) leak, its contribution to the NMVOC is indicated in brackets. When comparing the NMVOC values with the 25 mg/m<sup>3</sup> guideline, the OFP contributions should be subtracted. Control of atmospheric alcohols is important to the water recovery system engineers, hence total alcohols were also assessed in each sample. Formaldehyde is quantified separately. These five indices are summarized below:

<u>Sample Location</u>	<u>Date/Type</u>	<u>NMVOCs [OFP]</u> (mg/m <sup>3</sup> )	<u>T Value<sup>a</sup></u> (units)	<u>Alcohols</u> (mg/m <sup>3</sup> )	<u>Formaldehyde</u> (mg/m <sup>3</sup> )
Lab-GSC	8/06/01	74 [67]	0.39	3.3	0.031
SM-GSC	8/06/01	82 [76]	0.28	3.6	0.028
FGB-GSC	8/06/01	140 [61]	8.47	74.4	ns
MPLM	8/13/01	25 [10]	1.39	5.2	ns
Shuttle middeck-GSC	7/12/01(preflt)	0.5 [0]	0.02	0.2	ns
Shuttle middeck-GSC	7/23/01(EOM) <sup>b</sup>	159 [151]	0.53	7.9	ns
Acceptable Guideline>>		<25 [85000]	<1	<10	0.050

<sup>a</sup> Formaldehyde (methanal) and CO<sub>2</sub> not included in T calculation.

<sup>b</sup> ns = not sampled and EOM = end of mission sample

The FGB sample contained an unprecedented concentration of methanol (71 mg/m<sup>3</sup>, T contribution = 7.9). Since concomitant samples in the SM and Lab showed typical levels of methanol, we suspect a momentary source in the FGB, somehow occurring at the same time as the sample was acquired.

The MPLM sample shows that the overall pollution level was acceptable for first entry (T=1.39); however, it also shows that it was not a true first-entry sample. This can be deduced from the presence of OFP (10 mg/m<sup>3</sup>) in the sample. This could have come only from spread of this pollutant from the ISS complex into the MPLM after the hatch was opened and before the sample was taken. The alcohol concentration in the MPLM (5.2 mg/m<sup>3</sup>) was not a significant impact to the ISS alcohol load.

Taken as a whole, these data suggest that air pollutants were controlled to acceptable levels to protect crew health. The increase in the average OFP concentration from 7A GSC samples, and the higher quantity in the SM GSC sample suggest that OFP was continuing to leak from an ISS system in the SM faster than it was being scrubbed from the air. The concentration of OFP was far below any that would cause a health concern. To the extent that the samples were representative of each respective vehicle atmosphere, there was no evidence that the MPLM or *Discovery* contributed significantly to the alcohol load in the ISS atmosphere.

Enclosures

1: [Analytical Results of 7A.1 and STS-105 GSC Air Samples](#)

2: [T Values of 7A.1 and STS-105 Air Samples](#)

**TABLE 1**  
**ANALYTICAL RESULTS OF**  
**ISS 7A.1 AND STS-105 CONTAINER AIR SAMPLES**

CHEMICAL CONTAMINANT	CONCENTRATION (mg/m3)					
	AA03176 S/N 1006 LAB 8/6/01@	AA03177 S/N 1010 SERVICE MODULE 8/6/01@	AA03178 S/N 1005 FGB 8/6/01@	AA03179 S/N 1052 MPLM 1 8/13/01@	AA03173 S/N 1011 PREFLIGHT 8/10/01@	AA03175 S/N 1048 MIDDECK 11\14:06MET 8/22/01@ 11:15GMT
	11:47GMT	12:04 GMT	12:05GMT	19:43GMT	12:02EDT	
	<0.05	<0.05	<0.05	TRACE	<0.05	<0.05
	CIS-1,3-DICHLOROPROPENE	<0.05	<0.05	<0.05	<0.05	<0.05
	2-PENTENAL	<0.05	<0.05	<0.05	<0.05	<0.05
TRANS-1,3-DICHLOROPROPENE	TRANS-1,3-DICHLOROPROPENE	<0.05	<0.05	<0.05	<0.05	<0.05
	1,1,2-TRICHLOROETHANE	<0.05	<0.05	<0.05	<0.05	<0.05
	TOLUENE	TRACE	TRACE	TRACE	0.265	<0.05
	HEXANAL	TRACE	TRACE	TRACE	TRACE	TRACE
	MESITYL OXIDE	<0.05	<0.05	TRACE	<0.05	<0.05
	1,2-DIBROMOETHANE	<0.05	<0.05	<0.05	<0.05	<0.05
BUTYL ACETATE	BUTYL ACETATE	TRACE	TRACE	TRACE	TRACE	<0.05
	TETRACHLOROETHENE	<0.05	<0.05	TRACE	<0.05	<0.05
	CHLOROBENZENE	<0.05	<0.05	<0.05	<0.05	<0.05
	ETHYL BENZENE	TRACE	TRACE	TRACE	TRACE	<0.05
	M- + P-XYLENES	TRACE	TRACE	TRACE	<0.05	<0.05
	2-HEPTANONE	TRACE	TRACE	<0.05	<0.05	<0.05
CYCLOHEXANONE	CYCLOHEXANONE	TRACE	TRACE	TRACE	<0.05	<0.05
	HEPTANAL	TRACE	TRACE	TRACE	TRACE	<0.05
	STYRENE	<0.05	<0.05	<0.05	<0.05	<0.05
	1,1,2,2-TETRACHLOROETHANE	<0.05	<0.05	<0.05	<0.05	<0.05
	O-XYLENE	TRACE	0.054	TRACE	TRACE	<0.05
	1,3,5-TRIMETHYLBENZENE	<0.05	<0.05	<0.05	<0.05	<0.05
1,2,4-TRIMETHYLBENZENE	1,2,4-TRIMETHYLBENZENE	<0.05	<0.05	<0.05	<0.05	<0.05
	1,3-DICHLOROBENZENE	<0.05	<0.05	<0.05	<0.05	<0.05
	1,4-DICHLOROBENZENE	<0.05	<0.05	<0.05	<0.05	<0.05
	1,2-DICHLOROBENZENE	<0.05	<0.05	<0.05	<0.05	<0.05
	1,2,4-TRICHLOROBENZENE	<0.05	<0.05	<0.05	<0.05	<0.05
	HEXAChLORO-1,3-BUTADIENE	<0.05	<0.05	<0.05	<0.05	<0.05
TARGET COMPOUNDS (TOXIC)						
1,3-BUTADIENE	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
ETHYLENE OXIDE	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
CARBON DISULFIDE	TRACE	TRACE	TRACE	TRACE	<0.05	<0.05
2-METHYL-2-PROPENAL	<0.05	<0.05	TRACE	TRACE	<0.05	<0.05
3-BUTEN-2-ONE	<0.05	<0.05	TRACE	TRACE	<0.05	<0.05
DIMETHYLDISULFIDE	<0.05	<0.05	TRACE	<0.05	<0.05	<0.05
2-ETHOXYETHANOL	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
OCTAMETHYLCYCLOTETRASILOXANE	0.568	0.335	1.220	0.699	TRACE	TRACE
NON-TARGET COMPOUNDS						
OCTAFLUOROPROpane***	67.193	75.496	60.758	9.771	BL	150.584
CHLOROPENTAFLUOROETHANE	0.014	0.014	0.012	BL	BL	0.015
BROMOTRIFLUOROMETHANE	0.021	0.019	0.012	BL	BL	0.295
2-METHYLPROPANE	0.029	0.029	BL	0.027	BL	BL
TRIMETHYLSILANOL	0.072	0.052	0.062	1.737	BL	BL
1,3-DIOXOLANE	0.023	0.030	0.020	0.012	BL	BL
2-METHYLPROPANENITRILE	0.004	0.005	0.004	BL	BL	BL
CYCLOHEXANE	0.006	0.007	0.006	0.153	BL	BL
HEXAMETHYLCYCLOTRILOXANE	0.990	0.890	1.780	1.931	0.140	0.022
LIMONENE	0.074	0.097	0.072	0.015	BL	0.003
DECAMETHYLCYCLOPENTASILOXANE	0.326	0.336	0.450	0.250	BL	0.009

CHEMICAL CONTAMINANT	CONCENTRATION (mg/m <sup>3</sup> )					
	AA03176 S/N 1006 LAB 8/6/01@ 11:47GMT	AA03177 S/N 1010 SERVICE MODULE 8/6/01@ 12:04 GMT	AA03178 S/N 1005 FGB 8/6/01@ 12:05GMT	AA03179 S/N 1052 MPLM 1 8/13/01@ 19:43GMT	AA03173 S/N 1011 PREFLIGHT 8/10/01@ 12:02EDT	AA03175 S/N 1048 MIDDECK 11\14:06MET 8/22/01@ 11:15GMT
	TOTAL ALCOHOLS PLUS ACETONE	3.273	3.619	74.371	5.203	0.160
	TARGET COMPOUNDS (GC)***					
	ETHYLENE	<0.6	<0.6	<0.6	<0.6	<0.6
	CARBON MONOXIDE	<1.1	TRACE	<1.1	2.400	<1.1
	METHANE	0.750	0.730	0.710	1.900	1.100
	HYDROGEN	<1.6	<1.6	<1.6	TRACE	<1.6
	CARBON DIOXIDE	5300.000	5500.000	5700.000	1500.000	1341.000
TOTAL CONCENTRATION (NON-METHANE HYDROCARBONS)	73.800	82.100	140.000	24.900	0.480	159.000

< : Value is less than the laboratory report detection limit.

TRACE: Amount detected is sufficient for compound identification only. Calculations are based on one-half of the laboratory report detection limit (1.1 mg/m<sup>3</sup> for CO; 0.2 mg/m<sup>3</sup> for CH<sub>4</sub>; 1.6 mg/m<sup>3</sup> for H<sub>2</sub>; 0.05 mg/m<sup>3</sup> for VOCs; and 0.02 mg/m<sup>3</sup> for propenal.)

BL: Area below the search routine limit (<20% of the fluorobenzene peak area).

\*\*\*Measurements are calibrated by multi-point initial calibration and verified by mid-point continuing calibration.

NOTE: High levels (above 1.5ppm) of Methanol, Ethanol, Acetone, Isopropanol and 2-Butanone are routinely reported based on calibrated GC-FID measurements.

**TABLE 2**  
**ANALYTICAL RESULTS OF**  
**ISS 7A.1 AND STS-105 CONTAINER AIR SAMPLES**

CHEMICAL CONTAMINANT	T-VALUE (180-d SMAC)				T-VALUE (7-d SMAC)	
	AA03176 S/N 1006	AA03177 S/N 1010	AA03178 S/N 1005	AA03179 S/N 1052	AA03173 S/N 1011	AA03175 S/N 1048
	LAB	SERVICE MODULE	FGB	MPLM 1	PREFLIGHT	MIDDECK
	8/6/01@ 11:47GMT	8/6/01@ 12:04 GMT	8/6/01@ 12:05GMT	8/13/01@ 19:43GMT	8/10/01@ 12:02EDT	11\14:06MET 8/22/01@ 11:15GMT
TARGET COMPOUNDS (TO-14/POLAR)***						
FREON 12	0.000	0.000	ND	ND	ND	0.000
CHLOROMETHANE	ND	ND	ND	0.001	ND	0.001
FREON 114	ND	ND	ND	ND	ND	ND
METHANOL	0.030	0.034	7.861	0.034	0.003	0.012
ACETALDEHYDE	0.047	0.045	0.192	0.038	0.006	0.035
VINYL CHLORIDE	ND	ND	ND	ND	ND	ND
BROMOMETHANE	ND	ND	ND	ND	ND	ND
ETHANOL	0.001	0.001	0.002	0.000	0.000	0.001
CHLOROETHANE	ND	ND	ND	ND	ND	ND
ACETONITRILE	0.004	ND	0.004	ND	ND	0.004
PROPENAL	ND	ND	ND	0.333	ND	ND
ACETONE	0.004	0.004	0.004	0.042	0.000	0.004
PROPANAL	0.007	0.007	0.007	0.030	0.002	0.002
2-PROPANOL	0.002	0.002	0.002	0.009	0.000	0.033
FREON 11	ND	ND	ND	0.000	ND	ND
FURAN	ND	ND	ND	ND	ND	ND
ACRYLONITRILE	0.009	0.009	0.009	ND	ND	ND
PENTANE	ND	ND	ND	0.000	ND	ND
2-METHYL-2-PROPANOL	0.000	0.000	0.000	0.001	ND	0.000
METHYL ACETATE	ND	ND	0.000	ND	ND	ND
1,1-DICHLOROETHENE	ND	ND	ND	ND	ND	ND
DICHLOROMETHANE	0.041	0.043	0.036	0.298	ND	0.006
3-CHLOROPROPENE	ND	ND	ND	ND	ND	ND
FREON 113	ND	ND	ND	0.000	ND	ND
N-PROPANOL	0.001	0.001	0.000	0.001	ND	ND
1,1-DICHLOROETHANE	ND	ND	ND	ND	ND	ND
BUTANAL	0.006	0.006	0.006	0.006	0.001	ND
2-BUTANONE	0.001	0.001	0.001	0.019	0.001	0.001
1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	ND
2-METHYLFURAN	ND	ND	ND	ND	ND	ND
ETHYL ACETATE	0.000	0.000	0.000	0.000	ND	ND
HEXANE	ND	ND	ND	0.000	ND	ND
CHLOROFORM	ND	ND	ND	0.005	ND	ND
2-BUTENAL	0.015	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	0.025	0.025	0.025	ND	ND	ND
1,1,1-TRICHLOROETHANE	ND	ND	ND	0.000	ND	ND
N-BUTANOL	0.005	0.005	0.003	0.014	0.000	0.000
BENZENE	0.125	ND	ND	0.125	ND	ND
CARBON TETRACHLORIDE	ND	ND	ND	ND	ND	ND
2-PENTANONE	0.000	0.000	0.000	ND	ND	ND
PENTANAL	0.005	0.005	0.005	0.005	ND	0.001
1,2-DICHLOROPROPANE	ND	0.001	ND	0.004	ND	ND
1,4-DIOXANE	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	ND	ND	ND	ND	ND	ND
2,5-DIMETHYLFURAN	ND	ND	ND	ND	ND	ND
4-METHYL-2-PENTANONE	ND	ND	ND	0.000	ND	ND

CHEMICAL CONTAMINANT	T-VALUE (180-d SMAC)				T-VALUE (7-d SMAC)	
	AA03176 S/N 1006	AA03177 S/N 1010	AA03178 S/N 1005	AA03179 S/N 1052	AA03173 S/N 1011	AA03175 S/N 1048
	LAB	SERVICE MODULE	FGB	MPLM 1	PREFLIGHT	MIDDECK
	8/6/01@ 11:47GMT	8/6/01@ 12:04 GMT	8/6/01@ 12:05GMT	8/13/01@ 19:43GMT	8/10/01@ 12:02EDT	11\14:06MET 8/22/01@ 11:15GMT

CIS-1,3-DICHLOROPROPENE	ND	ND	ND	ND	ND	ND
2-PENTENAL	ND	ND	ND	ND	ND	ND
TRANS-1,3-DICHLOROPROPENE	ND	ND	ND	ND	ND	ND
1,1,2-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND
TOLUENE	0.000	0.000	0.000	0.004	ND	ND
HEXANAL	0.004	0.004	0.004	0.004	0.001	0.001
MESITYL OXIDE	ND	ND	ND	0.001	ND	ND
1,2-DIBROMOETHANE	ND	ND	ND	ND	ND	ND
BUTYL ACETATE	0.000	0.000	0.000	0.000	ND	ND
TETRACHLOROETHENE	ND	ND	ND	0.001	ND	ND
CHLOROBENZENE	ND	ND	ND	ND	ND	ND
ETHYL BENZENE	0.001	0.001	0.001	0.001	ND	ND
M- + P-XYLENES	0.000	0.000	0.000	0.000	ND	ND
2-HEPTANONE	0.001	0.001	0.001	ND	ND	ND
CYCLOHEXANONE	0.000	0.000	0.000	0.000	ND	ND
HEPTANAL	0.004	0.004	0.004	0.004	0.001	ND
STYRENE	ND	ND	ND	ND	ND	ND
1,1,2,2-TETRACHLOROETHANE	ND	ND	ND	ND	ND	ND
O-XYLENE	0.000	0.000	0.000	0.000	ND	ND
1,3,5-TRIMETHYLBENZENE	ND	ND	ND	ND	ND	ND
1,2,4-TRIMETHYLBENZENE	ND	ND	ND	ND	ND	ND
1,3-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND
1,2,4-TRICHLOROBENZENE	ND	ND	ND	ND	ND	ND
HEXACHLORO-1,3-BUTADIENE	ND	ND	ND	ND	ND	ND

TARGET COMPOUNDS (TOXIC)	ND	ND	ND	ND	ND	ND
1,3-BUTADIENE	ND	ND	ND	ND	ND	ND
ETHYLENE OXIDE	ND	ND	ND	ND	ND	ND
CARBON DISULFIDE	0.002	0.002	0.002	0.002	ND	ND
2-METHYL-2-PROPENAL	ND	ND	0.015	0.015	ND	ND
3-BUTEN-2-ONE	ND	ND	0.058	0.058	ND	ND
DIMETHYLDISULFIDE	ND	ND	0.125	ND	ND	ND
2-ETHOXYETHANOL	ND	ND	ND	ND	ND	ND
OCTAMETHYLCYCLOTETRAKSILOXANE	0.047	0.028	0.102	0.058	0.000	0.000

NON-TARGET COMPOUNDS	0.001	0.001	0.001	0.000	BL	0.002
OCTAFLUOROPROPANE***	0.000	0.000	0.000	BL	BL	0.000
CHLOROPENTAFLUOROETHANE	0.000	0.000	0.000	BL	BL	0.000
BROMOTRIFLUOROMETHANE	0.000	0.000	0.000	BL	BL	0.000
2-METHYLPROPANE	0.000	0.000	BL	0.000	BL	BL
TRIMETHYLSILANOL	0.002	0.001	0.002	0.047	BL	BL
1,3-DIOXOLANE	0.001	0.001	0.001	0.000	BL	BL
2-METHYLPROPANENITRILE	0.000	0.001	0.001	BL	BL	BL
CYCLOHEXANE	0.000	0.000	0.000	0.001	BL	BL
HEXAMETHYLCYCLOTRIKSILOXANE	0.110	0.099	0.198	0.215	0.002	0.000
LIMONENE	0.000	0.000	0.000	0.000	BL	0.000
DECAMETHYLCYCLOPENTASILOXANE	0.022	0.022	0.030	0.017	BL	0.000

TARGET COMPOUNDS (GC)***
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CHEMICAL CONTAMINANT	T-VALUE (180-d SMAC)					T-VALUE (7-d SMAC)
	AA03176 S/N 1006	AA03177 S/N 1010	AA03178 S/N 1005	AA03179 S/N 1052	AA03173 S/N 1011	AA03175 S/N 1048
	LAB	SERVICE MODULE	FGB	MPLM 1	PREFLIGHT	MIDDECK
	8/6/01@ 11:47GMT	8/6/01@ 12:04 GMT	8/6/01@ 12:05GMT	8/13/01@ 19:43GMT	8/10/01@ 12:02EDT	11\14:06MET 8/22/01@ 11:15GMT
	ND	ND	ND	ND	ND	ND
	ND	0.050	ND	0.218	ND	0.391
	0.000	0.000	0.000	0.001	0.000	0.006
ETHYLENE						
CARBON MONOXIDE						
METHANE						
HYDROGEN						
CARBON DIOXIDE	0.408	0.423	0.438	0.115	0.100	0.262
<b>TOTAL T-VALUE</b>	0.797	0.706	8.909	1.497	0.117	0.789

ND : Value is less than the laboratory report detection limit.

BL: Area below the search routine limit (< 20% of the fluorobenzene peak area).

Note: Number of decimal places in T-Values do not represent significant figures of measurements.

\*\*\*Measurements are calibrated by multi-point initial calibration and verified by mid-point continuing calibration.